**NAVIGATION STUDY FOR
JACKSONVILLE HARBOR, FLORIDA**

**DRAFT INTEGRATED GENERAL REEVALUATION REPORT II
AND
SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT**

APPENDIX A
ENGINEERING

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ENGINEERING

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JACKSONVILLE HARBOR, FLORIDA
APPENDIX A
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A. INTRODUCTION

1. General. This Appendix presents the discussion of applicable design considerations and construction methods utilized to adequately address the project requirements and to establish a basis for the cost estimates. General requirements for real estate and operation and maintenance are also presented. This Appendix has been prepared in accordance with the applicable policy guidance as contained in ER 1110-2-1150, Engineering and Design for Civil Works Projects; ER 1110-2-1403, Studies by Coastal, Hydraulic, and Hydrologic Facilities and Others; EM 1110-2-1613, Hydraulic Design of Deep-Draft Navigation Projects; ER 1110-2-1404, Hydraulic Design of Deep Draft Navigation Projects; and ER 1130-2-520, Navigation and Dredging Operations and Maintenance Policies. All soundings presented in this report are relative to Mean Lower Low Water (MLLW) based on the latest tidal epoch available from NOAA and the project is located geospatially in the North American Datum of 1983 (NAD83).

2. National Economic Development Plan (NED). The NED plan combines channel widening measures necessary for safe and efficient navigation of the project design vessel along with the deepening of the Federal channel project depth from an existing -40 feet to -45 feet, MLLW. In addition, two new Turning Basins have been designed to accommodate the design vessel and provide economic benefits. The dimensions of the proposed expansion features are irrespective of the final depth chosen for the project and all features were applied to each foot of a 1-foot incremental analysis of additional depth to the existing project from -41 to -50 feet, MLLW. An overview of the location and vicinity of the Jacksonville Harbor Federal Navigation project is shown on Plate 1.

3. Tentatively Selected Plan (TSP). The non-Federal local sponsor, Jacksonville Port Authority (JAXPORT), has requested that a Locally Preferred Plan (LPP) which incorporates an additional 2 feet of depth to the NED Plan be considered. An approval of the LPP Waiver Package by the Assistant Secretary of the Army for Civil Works (ASA-CW) to deviate from the NED Plan results in the LPP being adopted as the TSP, thus setting the project depth at -47 feet, MLLW. A discussion of the plan formulation involved in the selection of the TSP is presented in the Main portion of this Report. Plan view details of the existing project and TSP are shown on Plates 2 thru 4.

B. HYDROLOGY AND HYDRAULICS

4. General. The St. Johns River is the longest river in Florida, meandering more than 300 statute miles. The river discharges into the Atlantic Ocean at Mayport in Duval County. The total elevation drop from its headwaters to the Atlantic Ocean is less than 30 feet—an average slope of about one inch per mile.

Over most of its length, the river's average depth is relatively shallow. However, the 26-mile stretch of river from the mouth to downtown Jacksonville (the deepest segment) has an average depth of approximately 30 ft. Many small rivers, creeks, and tributaries feed into the St. Johns River, increasing the overall river flow, and affecting the tidal signal, especially during storm events. Some of the larger rivers and creeks along the lower portion of the St. Johns River include: Pablo Creek, Sisters Creek, Clapboard Creek, and Cedar Point Creek. Others, farther upriver, include: Dunn Creek, Broward River, Trout River, Arlington River, and Ortega River.

The St Johns River runs through the city of Jacksonville, located in northeast Florida. Deep-draft vessels transit as far as downtown Jacksonville, or about 24 miles upriver from the confluence with the Atlantic Ocean. Beyond this point, commercial traffic is light, and comprised mostly of tug-assisted barges.

The project area for this study includes Jacksonville Harbor main navigation channel which is about 23 miles long and extends from the river mouth to near downtown Jacksonville. Existing depths in the navigation channel range from 34 ft, between the Talleyrand Terminal and downtown, to 42 ft, at the entrance.

Specific objectives for the re-evaluation of Jacksonville Harbor include: determining if alleviating light loading, tidal delay, or other commercial navigation limitations would produce benefits that justify additional deepening below the existing 40-foot project depth from the entrance channel to river mile 13.1 to the TSP (LPP) project depth of 47 ft MLLW; evaluating measures including wideners along the Trout River Cut Range which would reduce navigation restrictions and improve ship traffic safety; examining the impact of channel deepening on the required capacity of upland confined disposal facilities and the offshore dredge material disposal site; evaluating the impact of deepening and widening measures on sediment shoaling rates and future maintenance dredging requirements; examining the hydrodynamic and environmental effects of the deepening and widening measures on salinity, water age and water quality as well as key ecological indicators.

5. Tides. The effect of tides on the river is significant. Tidal influences are prevalent from the mouth of the river to slightly more than 100 statute miles upriver, near Georgetown, where the tide becomes negligible. The exact point where the river becomes non-tidal varies, depending on the strength of the tide signal (e.g., spring or neap tides), and the interaction of the tide with the variable river flow. Tidal effects have been reported as far south as Lake Harney, upstream of DeLand.

According to the National Oceanic and Atmospheric Administration[1], the mean range of tide decreases from 5.5 feet at the ocean to 4.5 feet at Mayport within a 2 mile distance. The jetties and the river topography effectively damp the signal as it progresses into the entrance. **Error! Reference source not found.**1 summarizes the mean range of tide (mean high water - mean low water) at representative locations. The total flow in the lower reaches of the river is comprised of about 80%-90% tide-induced flow, with the remaining flow caused by wind, freshwater inflow (from tributaries and rain), and industrial and treatment plant discharges. The river flow generally increases downstream, with the highest flows occurring at the mouth of the river. The total discharge of the river is normally greater than 50,000 cubic feet per second (cfs) and will often exceed 200,000 cfs. River flow is seasonal, generally following the seasonal rain patterns with higher flows occurring in the late summer to early fall, and lower flows occurring in the winter months. The average annual non-tidal discharge at the river mouth is approximately 15,000 cfs.

In the St. Johns River, the tidal current consists of saltwater flow interacting with freshwater discharge. According to the U.S. Geological Survey seawater moving upstream from the mouth of the St. Johns River mixes with the river water to form a zone of transition. The chemical character of the water in this zone varies from seawater near the coast to freshwater farther inland. Between the City of Jacksonville and the ocean, the river shows some vertical stratification between seawater and overlying river water. Daily maximum chloride concentrations in the river range from 2,000 mg/L (4 ppt) at the Main Street Bridge to 19,000 mg/L (35 ppt) at Mayport 50 percent of the days. At Drummond Point, about halfway between these two sites, daily maximum chloride concentrations exceeded 10,000 mg/L (18 ppt) about 50 percent of the days and exceeded 15,000 mg/L (27 ppt) less than 7 percent of the days.[2]

6. Currents. The currents are strong in the river as far upstream as Jacksonville. The velocity of the current between the jetties is 1.9 knots on the flood and 2.3 knots on the ebb. At downtown Jacksonville (Commodore Point), the velocity of current is about 1 knot. The winds have considerable effect on the water level and velocity of the currents. Strong northerly and northeasterly winds raise the water level about 2 feet at Jacksonville. Strong southerly and southwesterly winds lower the water level about 1 to 1.5 feet, increase the ebb, and decrease or interrupt the flood.[3]

7. Sea Level Rise. Throughout geologic history global sea level variations, both rise and fall, have occurred. Two processes are predominantly responsible for

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1 *Tide Tables 1997 High and Low Water Predictions, East Coast of North South America Including Greenland*, Issued 1996, National Oceanic and Atmospheric Administration, National Ocean Service, 241.

2 *Appraisal of the Interconnection Between the St. Johns River and the Surficial Aquifer, East-Central Duval County, Florida*, U.S. Geological Survey, Water Resources Investigations Report 82-4109, Tallahassee, Florida, 1983, 5.

3 United States Coast Pilot, Atlantic Coast: Cape Henry to Key West, 1993 (29th) Edition, U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Ocean Service, 153-155.

relative changes in sea level: change in the absolute water level of oceans and the subsidence or uplift of land by geologic processes.

Relative sea level (RSL) refers to local elevation of the sea with respect to land, including the lowering or rising of land through geologic processes such as subsidence and glacial rebound. It is anticipated that sea level will rise within the next 100 years. To incorporate the direct and indirect physical effects of projected future sea-level change on design, construction, operation, and maintenance of coastal projects, the U.S. Army Corps of Engineers (USACE) has provided guidance in the form an Engineering Circular, EC 1165-2-212.

EC 1165-2-212 provides both a methodology and a procedure for determining a range of sea level change estimates based on global sea level change rates, the local historic sea level change rate, the construction (base) year of the project, and the design life of the project. Three estimates are required by the guidance, a Baseline estimate representing the minimum expected sea level change, an Intermediate estimate, and a High estimate representing the maximum expected sea level change.

Adjusting equation (2) to include the historic global mean sea-level change rate of +1.7 mm/year results in updated values for the variable b being equal to 2.71E-5 for modified NRC Curve I (Intermediate), 7.0E-5 for modified NRC Curve II, and 1.13E-4 for modified NRC Curve III (High).

$$\textit{Equation 2: } E(t) = 0.0017t + bt^2$$

Equation (3) of EC 1165-2-212 Appendix B calculates eustatic sea level change over the life of the project. E(t) is eustatic sea level change and b is a constant provided in EC 1165-2-212; t_1 is the time between the project's construction date and 1992 and t_2 is the time between a future date at which one wants an estimate for sea-level change and 1992 (or $t_2 = t_1$ + number of years after construction (Knuuti, 2002)). For example, if a designer wants to know the projected eustatic sea-level change at the end of a project's period of analysis, and the project is to have a fifty year life and is to be constructed in 2009, $t_1 = 2009 – 1992 = 17$ and $t_2 = 2059 – 1992 = 67$.

$$\textit{Equation 3: } E(t_2) - E(t_1) = 0.0017(t_2 - t_1) + b(t_2^2 - t_1^2)$$

Modifying equation (3) to include site-specific sea level change data, results in an equation for Relative Sea Level (RSL). This equation is used to estimate Baseline, Intermediate and High sea level change values over the life of the project.

$$RSL(t_2) - RSL(t_1) = (e+M)\,(t_2 - t_1) + b(t_2^2 - t_1^2)$$

$RSL(t_1)$ and $RSL(t_2)$ are the total RSL at times t_1 and t_2, and the quantity $(e + M)$ is the local change in sea level in m/year that accounts for the eustatic change as well as uplift or subsidence. The quantity $(e+M)$ is found from the nearest tide gage with a tidal record of at least 40 years.

Based on historical sea level measurements taken from NOS gage 8720218 at Mayport, Florida, the historic sea level rise rate *(e+M)* was determined to be 2.29 +/- .31 mm/year (0.0076 ft/year) (http://tidesandcurrents.noaa.gov/sltrends/index.shtml). The project base year was specified as 2015, and the project life was projected to be 50 years. Table 2 shows the results of equation (3) every five years, starting from the base year of 2015. From this table, the average baseline, intermediate, and high sea level change rates were found to be +2.29 mm/year (0.0078 ft/year), +4.67 mm/year (0.0174 ft/year), and +12.05 mm/year (0.0479 ft/year), respectively. Figure 1 shows the three levels of projected future sea level change for the life of the project.

The local rate of vertical land movement is found by subtracting regional MSL trend from local MSL trend. The regional mean sea level trend is assumed equal to the eustatic mean sea level trend of 1.7 mm/year. Therefore at Jacksonville Harbor, there is 0.59 mm/year of subsidence.

Engineering

The total regional sea level rise predicted by the three scenarios (baseline, intermediate, and high) will not have a significant impact to the performance of the Jacksonville Harbor navigation project. Potential impacts of rising sea level include overtopping of waterside structures, increased shoreline erosion, and flooding of low lying areas. A positive potential impact of sea level rise on the project is a reduction in required maintenance due to increased depth in the channel.

In general, regional sea level rise (baseline, intermediate, and high) will not affect the function of the project alternatives or the overall safety of the design vessel. While there is expected to be a small increase in tidal surge and penetration for all three scenarios, the structural aspects of the project will be either unaffected or can be easily adapted to accommodate the change.

Environmental

Cumulative environmental impacts due to changes in salinity, water age, and water quality, associated with the historic sea level rise (0.39 ft) and 155 MGD upstream river water withdrawal and the adaptive management analysis of changes associated with the intermediate and high sea level rise at 50 years after construction of the Jacksonville Harbor Deepening Project are described in the Hydrodynamics and Transport for Environmental Impacts paragraph of this section.

8. Storm Surge and Sea Level Rise. In order to evaluate the potential impacts of the deepening project to storm surge a coupled hydrodynamic and wave modeling system, ADCIRC (hydrodynamic) plus SWAN (wave) has been setup and calibrated for two historic storm events. A description of the setup and calibration is located in Attachment J. Hydrodynamic Modeling for Storm Surge and Sea Level Change. Preliminary results indicate the 47 ft project alternative has a minimal affect on the mean low water and mean high water tidal datums and causes no significant increase in peak storm surge elevations. This modeling effort is in progress to provide storm event surge assessment including USACE sea level rise rates (EC

1165-2-212 – Sea Level Change Considerations for Civil Works Programs) for the proposed project alternative channel deepening.

9. Methodology. In order to support project design and evaluate project impacts, a comprehensive hydraulic analysis approach including data mining, data collection and a suite of hydrodynamic and transport models was implemented. Attachment E. Hydrodynamic Modeling and Field Data Summary, describes the approach for modeling, data mining and data obtained during the 2009 field data collection. Field data used in this feasibility study include data previously collected by the SJRWMD, USGS, NOAA, and NOS and a USACE 2009 field measurement study. The USACE 2009 field measurements were obtained using underway shipboard and mounted instrument platforms that collected data associated with tidal flows, discharge from the St. Johns River, Intracoastal Waterway and major tributaries, water surface elevations, along-channel and cross-channel gradients in velocity, salinity, depth, temperature and suspended sediment concentration. These data were used for input, calibration, and validation for a comprehensive modeling task. The hydrodynamic modeling task included the Adaptive Hydraulics Model (AdH), a two-dimensional hydrodynamic and sediment transport model of the Federal Channel and St. Johns River Estuary system and the ADvanced CIRCulation Model (ADCIRC), a coastal circulation and storm surge model and development of the SJRWMD Water Supply Impact Study (WSIS), Environmental Fluid Dynamics Computer Code (EFDC) and EFDC/CE-QUAL-ICM TMDL models for the Jacksonville Harbor GRR2 to assess the effect of the Harbor deepening project on salinity, water age and water quality. Coastal processes were investigated using the Coastal Modeling System (CMS) in the vicinity of the St Johns River entrance, in order to evaluate shoaling due to littoral transport and to assess the potential impacts on the adjacent beaches due to channel deepening.

In order to provide a more consistent and improved set of water level and current boundary conditions for the task specific models, AdH, CMS, and EFDC, ADCIRC modeling was conducted for a domain that includes adjacent inlets, St. Marys, Nassau Sound, Ft George, St Augustine, and the AIWW. A detailed description of the ADCIRC hydrodynamic waterlevel and current boundary modeling is located in Attachment F. ADCIRC Boundary Conditions for Project Design and Impact Analysis.

The project alternative plans were evaluated using a St. Johns River circulation model in addition to ship simulator studies. The circulation models were developed by Corps of Engineers staff, using the hydrodynamic model AdH. Current velocities and flow fields were developed for all alternatives using AdH. The TSP, which is the Locally Preferred Plan with a project depth of 47 ft MLLW and a project length of 13.1 river miles, was determined to be the most effective and feasible plan. This alternative was then verified using AdH. Further details of this analysis are available in Attachment G. AdH Hydrodynamic Modeling for Ship Simulation, Riverine Channel Shoaling and Bank Impacts. Outputs from the AdH hydrodynamic model were then used as inputs into the ship simulator studies detailed in Attachment I. Ship Simulation Navigation Study for St. Johns River GRR-2 Improvement Project Data Report.

10. Channel Shoaling. In order to assess changes to shoaling patterns and volumes resulting from proposed channel modifications, two-dimensional hydrodynamic model applications were developed for riverine and coastal areas of the Jacksonville Harbor GRR2 project area.

In order to evaluate riverine channel shoaling rates and estimate future maintenance volumes due to the project, the AdH sediment transport processes were included in the model. The AdH sediment transport model for Jacksonville Harbor was run for three months from May 1 through July 31, 2009 for both existing condition and for the preliminary alternative with-project condition depth of 46-ft MLLW. The observed bed levels were compared with the model results. A reasonable agreement was obtained between the observed data and the model results. Additional AdH modeling has begun for the Locally Preferred Plan, which is the Tentatively Selected Plan, with an inner channel project depth of 47 ft MLLW and a length which extends from Mile 0 to Mile 13.1. This work will be completed prior to and included in the final draft of this GRR.

The AdH sediment transport model simulated the bed level changes for both existing and with-project (46-ft depth) conditions. Based on the simulations, the shoaling rates and volumes were computed that would result from the deepening and widening of the channel. The with-project condition results in an overall increase in shoaling volume by approximately fifteen percent. Model results for a subset of Section 1, from Cut 5 through Mile Point Cut-13, indicate no significant increase in shoaling volume rates due to the project alternative. Model results for Section 2, from Mile Point Cut-14/15 to Cut-42, indicate an increase by a factor of 5 in shoaling volume due primarily to the Blount Island Turning Basin project alternative feature in this Channel Section. Model results for Section 3A, from Mill Cove Cut-43 to Cut-45, indicate an increase in shoaling volume due primarily to the Brills Cut Turning Basin project alternative feature in this Channel Section. The average shoaling rates (based on the rates of bed displacement) are computed at the turning basin in the Mill Cove and Bartram Island area. Based on the average modeled shoaling rate of 0.0034 ft/day, an annual increase of 1.25 ft is predicted for the Blount Island Turning Basin. Similarly, based on an average modeled shoaling rate of 0.0044 ft/day an annual increase of 1.6 ft in the bed is predicted for the Brills Cut Turning Basin. The AdH hydrodynamic model for Jacksonville Harbor was used to investigate the effects of creating islands as a beneficial use of dredged material in Mill Cove. No significant effect on water levels and volumes of water flowing into and out of Mill Cove was observed by examining the model results. Slight reductions in water velocities can be expected to occur in the immediate vicinity of the islands. In addition, changes in sedimentation rates and patterns could occur in locations near the islands. A detailed description of the AdH hydrodynamic and sediment transport modeling and analysis is located in Attachment G. Hydrodynamic Modeling for Ship Simulation, Riverine Channel Shoaling and Bank Impacts.

In order to evaluate coastal processes and channel shoaling rates at the entrance to the St Johns River and estimate future maintenance volumes due to the project, the Coastal Modeling System (CMS-FLOW) was used. Attachment H. CMS Hydrodynamic Modeling for Coastal Processes & Channel Shoaling, documents the investigation of the coastal processes in the vicinity of the St Johns River entrance which provides a basis for evaluating the mechanisms which contribute to the coarse grained shoals frequently found in the Federal navigation channel between the jetties and for evaluating the impacts of channel deepening to the adjacent beaches due to changes in transport pathways at the entrance. A coastal process analysis of the St Johns River entrance was conducted including a historical shoaling estimate based on historical bathymetry surveys of the channel and adjacent areas and the coupled hydrodynamic wave and sediment transport model, CMS-FLOW.

Currents, waves, sediment transport, and morphology at the St Johns River Entrance form a coupled dynamic system. This complex system dictates the transport of littoral sediment into and out of the navigation channel and to or from adjacent beaches. In order to determine the pathways and transport rates in this inlet system a coastal inlet processes model was used to simulate historical morphologic changes. Attachment H. CMS Hydrodynamic Modeling for Coastal Processes & Channel Shoaling, presents the modeling results of recent changes to the inlet system-the entrance channel was deepened to a 50 ft MLLW project depth in 2012 by the Navy. Additional analyses are planned for the Jacksonville Harbor GRR2 modifications to the inlet system, but these are not expected to be significant since there will be only minor changes to the channel from the junction of the Federal Navigation Channel and the Mayport Entrance Channel to the seaward extent of the Federal Navigation Channel. The existing authorized civil works entrance channel is 800 ft wide and 42 ft MLLW (12.8m) deep (see Plates 2 through 4). The project alternatives under consideration include: widening the channel varying amounts (up to 300 ft) starting about 1.0 mi east of the Atlantic Intracoastal Waterway (AIWW) and extending about 4.8 mi up river; deepening the inner channel to 47 ft MLLW (LPP plan) for the majority of the project; deepening the entrance channel to 49 ft MLLW (LPP plan); providing advanced maintenance areas equal to 2 ft for existing shoaling areas and anticipated shoal areas; and providing turning basins adjacent to Blount Island and Brills Cut (see Plates 2 through 4). The US Navy (USN) has deepened the entrance channel, known as Bar Cut 3, through the inside of the jetties to the Mayport Entrance Channel, to a project depth of 50 ft MLLW.

In order to estimate the annual shoaling rate for the Bar Cut 3 Ebb Shoal section of the channel for the Mayport Deepening, the shoal volume for the simulated storm events were weighted proportionally to the significant wave and storm duration for storm events occurring in a one year period from September 2006 to August 2007. These weighted estimates of shoal volume for each event were summed to calculate an estimate of the annual shoaling in the Bar Cut 3 Ebb Shoal section of the channel. The annual shoal volume for the without Mayport condition is 47 KCY and for the with Mayport condition, 105 KCY. This represents an increase in annual shoal volume of 2.2 times. Similar to the volume the bed level change from the simulated storm events were weighted proportionally to the significant wave and storm duration for each of the storm events occurring in a one year period from September 2006 to August 2007 and summed to calculate an estimate of the annual bed level change in the Bar Cut 3 Ebb Shoal section of the channel. The estimated annual bed level change for the Mayport deepening is approximately 2.5 ft.

11. Bank and Ship Wake Impacts. At Jacksonville, a project purpose is to allow larger vessels with deeper drafts to sail in the deepened channel. Viewed in the context of the Bernoulli principle, the increased immersed vessel cross section as a fraction of the newly deepened channel cross section has a functional relationship with vessel wake generated. More specifically, the percentage of channel cross-section blocked by the submerged vessel is directly proportional to ship wake height. Vessel speed also has this relationship with wake. Although increasing vessel transit speeds is not a project purpose, and speed can be regulated through instruction and enforcement, more needs to be understood regarding the exact nature of the relationship between channel cross section blockage and generated vessel wake characteristics. An understanding of that relationship, and how it applies at Jacksonville is essential for describing vessel wake in the constructed project. Future wake characteristics must be understood to predict if the project will result in impacts to shore profile endurance. This insight is especially important in view of the existing situation, whereby identified locations along the river are experiencing bank erosion.

Using the guidance EM 1110-2-1100 Part II pp II-7-59 to II-7-61, drawdown has been calculated for the JAX HARBOR GRR-2 design vessel, SUSAN MAERSK, in the existing channel and in the deepened, with-project channel. Drawdown is one of several water surface disturbances created by a vessel as it passes through the water. Along the midsection of the vessel, there is a region of below average pressure, which corresponds with a lowering of the water surface elevation, and is referred to as vessel drawdown. Drawdown is the "long wave" component of vessel wake. The calculations indicate that ship wake in the near field (which is considered to be within a distance approximately equivalent to two ship lengths measured on either side, outward from the vessel sailing line) will not increase for the design vessel, using the newly available depth in the with-project condition, as long as vessel speed is held constant.

Additional analysis using the AdH ship wake model is being conducted to estimate ship wake, not only in the near field, but also at the adjacent shoreline along the vessel transit reach. Ship wake will be computed for the SUSAN MAERSK operating in the existing and deepened, with-project channel for both inbound and outbound transits under flood, ebb and slack tides. This work will be completed and presented in the revised Draft Report for the study.

12. Hydrodynamics and Transport for Environmental Impacts. The USACE-SAJ, as part of its General Re-evaluation Study to improve Jacksonville Harbor navigation, is assessing the effects of channel modifications on the general circulation, salinity, ecology, and water quality in the St Johns River. The Environmental Fluid Dynamics Code (EFDC) 3D hydrodynamic and transport model is used to characterize river circulation and salinity for pre- and post-project conditions. This study applied the model to simulate the without project condition and three project alternatives (navigation channel dredging to 44 ft, 46 ft, and 50 ft depth below mean lower low water for Segment 1, which is from east of the river mouth at Mile 0 to Mile 13.7) and analyzed the project impact during a six-year evaluation period. The six-year evaluation period includes the lowest river flow during any three-year period in the river’s 78-year flow record, as shown in

Attachment K. Hydrodynamic and Salinity Modeling for Ecological Impact Evaluation Figure 4.1, to ensure that assessed project impacts are greater than those during an average year. Therefore, this study's evaluation presents conservative estimates of the impacts of the Jacksonville Harbor Deepening Project. Additional EFDC Salinity modeling has been initiated for the Locally Preferred Plan, which is the TSP, with an inner channel project depth of 47 ft MLLW and a length which extends from Mile 0 to Mile 13.1. This work will be included in the final GRR. In the interim the 46 ft MLLW project, based on it's similarity to the 47 ft (46 ft includes the same range of depths as the LPP, but is 0.6 of a mile longer) and the sensitivity of salinity to channel depth in the 44ft, 46 ft, and 50 ft results, is considered representative of the LPP to evaluate impacts of the project. Attachment K. Hydrodynamic and Salinity Modeling for Ecological Impact Evaluation documents the setup, sensitivity analyses, validation, and preliminary application of the EFDC model to evaluate the direct impacts to salinity and water age of navigation channel modifications.

Cumulative impact EFDC model results associated with conditions for the historic sea level rise (0.39 ft) and 155 MGD upstream river water withdrawal at 50 years after construction of the 46 ft MLLW project alternative, show that the 46 ft MLLW alternative will likely increase future tide range by 0.2 ft at Long Branch and Main Street Bridge. Future salinity will likely increase by 0.6 – 1.0 ppt from Dames Point to the Buckman Bridge and will likely have very small change upstream of the Shands Bridge. The project doesn't significantly increase water age (similar to residence time) and therefore will likely not reduce future water circulation in the study area.

The USACE EFDC hydrodynamic, salinity, and water age model results provide input data for five ecological models, namely submerged aquatic vegetation (SAV), wetlands, fish, benthicmacroinvertebrates (BMI), and plankton. These ecological models provide the means to evaluate the potential effect of the Jacksonville Harbor Deepening Project on the ecological system in the Lower St. Johns River. The Appendix D. Ecological and Water Quality Modeling Reports describes the ecological modeling procedure, ecological modeling results, and impact on ecology of the project. Post-processing of the USACE model salinity and water age results for the 2015 (construction date) and 2065 (50 year project horizon) scenarios provided the ecological model inputs.

The Jacksonville Harbor Deepening GRR-2 environmental impact evaluation also included application of the SJRWMD TMDL version of the EFDC hydrodynamic models and the CE-QUAL-ICM water quality model to evaluate the key water quality parameters in the LSJR. Attachment L. Hydrodynamic and Water Quality Modeling for Environmental Impacts documents the setup, sensitivity analyses, calibration and validation, of the USACE TMDL EFDC/ CE-QUAL-ICM model to evaluate the impacts to water quality of navigation channel modifications. Project impact evaluation is in progress and will be included in the final project report, to be completed in the latter part of the fiscal year.

C. GEOTECHNICAL

13. <u>General.</u> The evaluation of the ground conditions for the deepening of the Jacksonville Harbor is based on a number of core boring programs drilled over a 50-year period. Many of the deepest, most useful core borings are the core borings that were drilled for the deepening of the harbor in the 1960's. The majority of the historic core borings were drilled using a drive sampler. Some core borings were drilled using the standard splitspoon.

The historic core borings were often drilled sufficiently deep to penetrate the materials that are to be dredged in the proposed current deepening of the channel. The material shown on the core logs above the excavated depths achieved during previous dredging events will now be shoaling materials; but, the materials shown below the depths achieved by the previous excavation represent undisturbed materials and/or virgin materials to be excavated. Pre-dredge surveys were used for determining the quantity of excavated material for the cost estimate.

In addition to the borings conducted over the past 50 years, a marine resistivity survey was conducted in 2009 to assist with sediment identification beneath the channel from Terminal Channel near downtown Jacksonville to the mouth of the St. Johns River. The variable presence of rock in the harbor has created differing site conditions during dredging. The resistivity survey was an effort to more closely estimate rock limits and sediment variation. A particular sediment's resistivity depends on the electrical properties of the grains, amount of porosity, water saturation and the pore water resistivity. In general for a limited water resistivity, clay with very high porosities shows very low resistivity; but solid limestone that has a low porosity, shows very high resistivity. Weathered limestone tends to show lower resistivities. Rock extent and quality can be inferred from the resistivity data.

A boring investigation was conducted subsequent to the resistivity survey to test the anomalies seen on the survey data. Old and new boring log data were plotted on resistivity profiles to estimate lithology changes between borings to form a database used to quantify the rock and various sediments within the dredge prism. The estimated rock areas were measured in one-foot slices in plan view to estimate the rock quantities for dredging.

14. <u>Geologic Setting.</u> The topography in the project area consists of relic marine terraces of Pleistocene age. The trend of these terraces is approximately that of the present coastline. The height of the terraces to the south of the Saint Johns River range from approximately 30 to 50 feet above sea level; the highest point is about 85 feet near Fort Caroline National Memorial. North of the river much of the area is covered by saltwater marshes with terrace heights rarely exceeding 30 feet.

Holocene and Pleistocene deposits of predominately sand and clayey sand with localized shell beds mantle the project area. These deposits are underlain by sand, shell, clay, and limestone/sandstone of Pliocene to late Miocene age. Collectively, the Holocene to late Miocene age deposits form the surficial aquifer which has a thickness that ranges from 50 to 100 feet in the project area.

The Hawthorn Group of middle Miocene age underlies the surficial aquifer throughout the project area, has a thickness ranging from 300 to 450 feet and consists mainly of clayey sand, clay and siliceous limestone with varying amounts of phosphate. The Hawthorn has an overall low permeability and functions as a confining bed that severely retards the movement of water between the surficial aquifer and the underlying Floridan Aquifer.

The Floridan Aquifer is the principal source of water in northeast Florida and throughout much of the state. Due to the hydraulic separation provided by the Hawthorn Formation and the upward gradient in the Floridan Aquifer, the proposed deepening of the St. Johns River will not adversely affect the Floridan Aquifer.

15. Surficial Aquifer. In 1981 an assessment of the interconnection between the St. Johns River and the surficial aquifer in east-central Duval County was completed by the U.S. Geological Survey. This assessment concluded that dredging operations in Jacksonville Harbor were not expected to significantly alter the hydrologic system since an interconnection between the shallow limestone and the river already exists and elevated chloride concentrations are present in the surficial aquifer. This document is U.S. Geological Survey Water - Resources Report 82-4109 and is included as Attachment A. This document was revisited by the USGS in light of the proposed new dredge depths. The USGS report is currently under final review regarding the chloride impact to the surficial aquifer, but it will be made available upon completion of USGS internal review. The minimal increase in river salinity from deepening and no increase in river elevation will not result in significant increase to the driving force that would further degrade the already impacted surficial aquifer within the immediate vicinity of the river.

Impacts would be possible where the surficial aquifer gradient is the least. The higher ground of the Ft. Caroline area would have a higher gradient toward the river than the area across the river along Hecksher Drive where the topography is flat and just above river elevation. Where the gradient is least, there is little resistance to infiltration of higher salinity water from the river. The heavier high salinity water will seek equilibrium with the fresher water in the surficial aquifer. The amount of recharge to the surficial aquifer and the sediment permeability will help determine the fresh water gradient toward the river and the location of the fresh water/saline water interface. Increased pumping rates in the surficial aquifer may reverse the gradient between the river water and the groundwater of the nearby land. This too will act to draw saline water inland.

16. Previous Investigations. Attachment B contains core boring logs, lab analysis and geological profiles for geotechnical investigations applicable to this study. Plates B-2 through B-5 show locations of core borings used for this re-evaluation. There are many more borings available, but those not used have already had dredging to the total depth of the boring and have little value for this study. The older boring logs included in Attachment B show differing coordinate system and elevation datum than the current proposed project, but their locations were corrected to NAD 83 and their elevations corrected to Mean Lower Low Water (MLLW) to be able to plot and include in the study.

17. Recent Investigations. A marine resistivity survey was conducted over the length of the harbor in late 2009 to estimate the extent of rock areas within the channel. Resistivity is a measure of the resistance to flow of electricity through a material. In general, earth materials that are hard and dense without free electrons have higher resistivity than those porous less dense materials. Simplistically, the rock to be dredged beneath the river channel should be displayed at higher resistivity than the sand, silt and clay sediments. However, as the rock becomes more porous and less well consolidated, the resistivity signature approaches that of sand, silt and clay, and it becomes difficult to differentiate between rock and softer sediments.

Using the resistivity survey data, a resistivity signature of suspected rock areas was tested during a drilling program of 50 borings conducted in 2010 along the length of the channel. These borings were drilled sufficiently deep to characterize the materials within the project for dredging or blasting. The borings coupled with the resistivity data allowed a more complete definition of the materials beneath the channel with the resistivity data filling in the gaps between borings. The report of the resistivity survey is included as Attachment C.

18. Materials Encountered.

Non-rock Areas

The project has been separated into rock and non-rock areas. Areas considered non-rock are reaches of the channel where the materials to be excavated will be predominately sand, silt or clay as indicated on the core logs and resistivity data. A non-rock area can and typically will contain some rock even if rock is not shown expressly in core logs. Non-rock areas downstream of the Intracoastal Waterway generally have beach quality sand at the surface. These same areas historically have sand that can be placed on the beach or in near-shore areas that contain previously recovered material from maintenance dredging. These same areas commonly contain shell beds too, and the recent boring logs also show shell beds that would downgrade the quality for placement of this material near or on-shore.

Also present along the channel within the proposed dredge prism are silts and clays, but these are minor compared to the volume of the sand and rock present. The silt and clay are primarily confined to limited intervals or areas along the channel. On the older boring logs there are gravels noted, but these are likely poorly cemented sandstone or limestone that are broken during split spoon sampling.

Rock Areas

A rock area is an area of the channel where the virgin materials to be excavated will be predominately rock materials as shown on the core logs and resistivity data. Rock can be sandstone, siltstone or limestone and generally occurs below elevation -40 feet MLLW. During the most recent deepening of the harbor, the majority of the rock was excavated using conventional rock cutting dredging equipment. At a number of locations, blasting was required to aid in the excavation of the rock. For cost estimating purposes for this deepening project, geological data suggest that 15% of the area within the channel boundaries was calculated to be rock at elevation -47 feet MLLW.

Rock Quality

Unconfined compressive strength of the rock is an indicator of the ease of dredging and the need to blast. Strength testing of cores from recent borings is displayed below. Strengths generally above 5,000 psi are considered sufficiently strong to require blasting. There are other characteristics that need to be evaluated for blasting, but the strength is an indicator. As can be seen from the table below, there is but one boring tested within the proposed dredge area that has strength above 5,000 psi.

Measured Rock Strengths

CORE BORING NUMBER	ELEVATION (MLLW)	UNIT LOAD (PSI)
CB-JHPM09-2	-46.6	140
CB-JHPM09-2	-52.0	5728
CB-JHPM09-6	-49.0	398
CB-JHPM09-7	-47.8	2435
CB-JHPM09-7	-50.1	935
CB-JHPM09-16	-48.4	1201
CB-JHPM09-16	-49.7	135
CB-JHPM09-17	-46.4	414
CB-JHPM09-18	-45.9	406
CB-JHPM09-42	-47.0	1949

There exists in the project area, strong massive rock that would ordinarily need to be blasted for economical excavation. During previous deepening, the dredge encountered strong rock in Cuts 12 to 14 where unconfined compressive strengths of 20 rock samples collected from the rock disposal area averaged over 5700 psi. In the recent deepening of the channel, blasting was required to remove strong rock; but, after the rock was blasted, the subsequent excavation of the blasted rock removed the rock to elevations below -42 feet MLLW. Some pinnacles and limited areas of resistant rock are expected to be encountered as residual from previous deepening.

Rock Pretreatment Requirements

Blasting for the deepening project was included in the cost estimate for this deepening, but may be limited due to the strength of the rock tested from the most recent borings. It is anticipated that all of the required dredging depths can be achieved using conventional dredging equipment with the aid of blasting. The quantity of rock that will require removal is estimated based on resistivity response in conjunction with the boring data. A Pretreatment Appendix is attached as Attachment D that describes considerations for blasting in the harbor deepening project.

19. Excavation.

Channel

The proposed project depth of -47 feet MLLW, plus applicable overdepths, construction of the channel wideners would involve excavation of unconsolidated materials along with rock. The unconsolidated materials and the soft to moderately hard rock could be excavated with a rock cutterhead hydraulic pipeline dredge. Pretreatment of the rock may be necessary and can be accomplished through several methods including punch barge or blasting. Once the rock is broken, it can be removed with several options including clamshell. The areas hatched on Plates B-2 to B-5 in Attachment B show where rock is projected at elevation –47 feet MLLW. Rock occurs above this elevation and generally increases in areal extent with increase in depth within the dredge prism. Lithology within the dredge prism along the channel is displayed on plates B-7 to B-11 as determined from the geological data. Additional Investigations will be required to enhance the existing data to bring it to Plans and Specifications standards.

Turning Basins

The Blount Island Turning Basin near the center of Cut 42 has several borings located within the turning basin limits south of the channel. These borings were used to characterize the sediments within these southern limits. Generally, the sediments near the center of the turning basin are predominantly sand that contains varying amounts of fines including clay. Sediments are predominantly silt and clay in the eastern portion of the turning basin. Below -40 feet MLLW there is poorly cemented calcareous sandstone to sandy limestone. Excavation of the unconsolidated sediments can be accomplished without the need for blasting, whereas the rock may require pretreatment to break it sufficiently for removal.

The geology beneath the Brills Cut Turning Basin at the west end of Cut 45 is based on the expected geology within the active river channel. There are no geologic data for the area of this turning basin outside the limits of the channel. It is reasonable to assume that the geology will be consistent with an active river channel at least for several feet below the surface of the sediment. Deeper borings within the river channel can be used to project the deeper virgin sediments into the turning basin located outside the limits of the channel. All the borings in the area show sand with varying fine content below the -40 feet MLLW to just below the base of the dredge prism. The material below about -42 feet MLLW should be undisturbed sediment. There are minor layers of silt or clayey sand within the section, but not great thicknesses. Highly weathered sandy limestone is found in one of 3 borings within the river channel contained in the turning basin. None of the material evident in the borings would require blasting, but that does not mean there are undetected pockets of rock that would require blasting within the limits of the turning basin. Additional borings will be performed in this turning basin to better define the materials expected.

20. Engineering Stability Analysis and Assumptions. Slope stability analyses were performed using SLOPE/W within the GeoStudio 2012 (Version 8.0) suite of software to determine the stability of the existing and proposed channel slopes in the vicinity of the North and South Jetty. The most critical (i.e., steepest slopes, most required slope cut) slope scenarios were analyzed. Engineering Manual (EM) 1110-2-1902 “Slope Stability” (dated 2003) was the guidance used. Slope geometry was based on information provided by a series of composite surveys performed between 2003 and 2012. It should be noted that several gaps in the survey data exist and some assumptions had to be made in geometry in order to perform the analyses. In addition, since the exact foundation elevations for both the north and south jetties are unknown, they were conservatively assumed to be at elevation -20.0 ft MLLW. It should also be noted that boring information along the jetties is sparse, with borings being spaced more than 1,000 feet from some areas of interest. This led to several conservative assumptions about the subsurface conditions at the jetty locations. Therefore, as noted above, it is recommended that additional subsurface information be gathered at the most critical areas for the design phase of this project, as well as, the acquisition of more detailed as-built and survey information of the jetties.

21. Existing Jetty Stability. The results of the slope stability analyses indicate that the most critical area was the South Jetty, near Station 180+00, for which the surveys showed an existing side slope steeper than one foot vertical to one and a half feet horizontal (1V:1.5H). Based on our analysis, the South Jetty in its current state has an inadequate factor of safety of 1.11. The survey data also indicates that there are several more areas for both the South and North Jetty where slopes are approaching 1V:1.5H. It should be noted that none of these areas will be impacted by the proposed harbor deepening, since they are in areas where the existing channel is both wide and deep enough that no dredging will be required. Also, design of jetty stabilization features was not performed as part of this study, as this is outside the scope of this project.

22. Jetty Stability with Tentatively Selected Plan. A slope stability analysis was performed to determine if the proposed dredge design template would impact the stability of the existing jetties located to the north and south of the proposed project. The most critical area was determined to be the North Jetty, near Station 213+00, for which surveys indicated that approximately 50 to 75 feet of horizontal cut of the existing slope will occur and the adjacent river bottom will be deepened by approximately 2 feet. In addition, by visual inspection it appears that this channel side slope is the steepest of the slopes that will be affected by the proposed deepening. Based on our analysis, the effected slope in this area will have an

adequate factor of safety of 1.33 for the planned deepening with the currently proposed channel template.

D. DESIGN AND CONSTRUCTION

23. General. A project location map is shown on Plate 1. The TSP Project depth is -47' MLLW for Segment 1; however, due to more pronounced environmental conditions such as wind, waves, and tides an additional 2 feet is included for the outer portion of the project between Entrance Channel Bar Cut-3 Station 0+00 and Bar Cut-3 Station 210+00, thus resulting in a -49' MLLW project depth for that reach. This additional 2 feet is already incorporated into the existing 40-foot project (42-foot for this reach) and will simply be carried forward into the proposed TSP providing an additional 2 feet for vessel underkeel clearance in this reach. In addition to depth there are improvements to the Federal channel that are necessary to facilitate the navigation of the design vessel as tested through ship simulation and a summary of these measures is provided in Table 3. The proposed TSP, to include limits of channel widening, is shown on Plates 2 through 4 and typical cross sections depicting the depth terminology and the contract dredging requirements are shown on Plate 36. In addition, Figures 3 through 237 provide a complete cross section analysis taken at a 100-foot station interval depicting the dredging template, side slopes, existing river bottom and the project's proximity to the St. Johns River shorelines for the entire project limits. Plan details are provided on Plates 5 through 29 showing project features and existing bathymetry.

24. Side Slopes. For estimating purposes, the average side slope for the proposed excavation was determined to be 1 vertical on 3 horizontal (1V:3H) for the majority of the project with the exception of those areas that have been identified where rock was identified to be prevailing below elevation -45' MLLW. In those locations the specified slope for construction would be vertical below that elevation and become 1V:3H above. The side slope plan is depicted on Plates 30 through 32. The design side slopes were derived from historical project information, an analysis of the materials to be dredged and existing channel topography.

25. Overdepths. An additional 1-foot of required overdepth and 1-foot of allowable overdepth are included in the estimated excavation quantities. The required overdepth would be necessary to facilitate future maintenance of the channel due to the existence of consolidated material at project depth. The allowable overdepth would be included to provide for inaccuracies in the dredging process and both overdepths are provided in accordance with ER-1130-2-520, Navigation and Dredging Operations and Maintenance Policies. Refer to Plate 36 for an explanation of all depth terminology used in this Report.

26. Advance Maintenance. Advance maintenance is dredging to a specified depth and/or width beyond the authorized channel dimensions in critical and fast-shoaling

areas to avoid frequent redredging and ensure the reliability and least overall cost of operating and maintaining the project authorized dimensions. For Jacksonville Harbor there is an existing Advance Maintenance authority, as provided by South Atlantic Division (SAD) on 17 October 1997, for an additional 2 feet of dredging throughout the entire project, see Figure 2. For purposes of the proposed project, an in-depth analysis has been performed that recommends locating the 2 feet of advance maintenance only in areas that are predicted to shoal the most rapidly thus avoiding any increase to the frequency of maintenance dredging that is currently performed for the existing project. The proposed advance maintenance is divided into five separate areas, see Plates 33 through 35 for exact location details. These areas represent similar surface areas to the previous advance maintenance areas presented in the 2002 GRR and also represent similar quantities of dredging. They have been strategically located based on the following five items: 1) Analyzed dredging projects over the last ten years following the deepening from -38' to -40' MLLW; 2) Received feedback from the St. Johns River Bar Pilots regarding recurring hotspots; 3) Past shoaling studies; 4) Use of historic surveys; and 5) Currently authorized advance maintenance areas and their performance. In addition, sediment transport modeling (ADH) analysis was used to further verify the placement of these locations with respect to the with-project future conditions. These items have been considered to maintain the lessened frequency of dredging in these areas to reduce future O&M costs and the Bar Pilots have been directly involved in the need for dredging to prevent draft restrictions in the channel that would lead to reduced benefits.

27. Disposal Area. It is anticipated that all of the construction material dredged from this project will be placed within the expanded Jacksonville Harbor Ocean Dredged Material Disposal Site (ODMDS), see Plate 37. There are opportunities for beneficial use of some of the material to be dredged in the form of placement in the nearshore, along the riverbank at erosion spots, or an artificial reef; however, these alternatives are not currently considered to be least cost and would require further development and permitting. It is assumed that these opportunities would be explored during a subsequent Value Engineering workshop during the PED Phase. It may also be possible for the local sponsor or other non-Federal partner to pay any additional cost associated with material placement in a location other than the Jacksonville ODMDS, if desired.

28. Construction Procedure. For cost estimating purposes all forms of dredging are evaluated singularly and in a possible combination of dredging equipment (Hopper, Clamshell, Backhoe, or Cutter-Suction). It is anticipated that this dredging equipment will be utilized along with some form of pretreatment for hard rock such as drilling and blasting, punch barges, and hydraulic or pneumatic hammers. Scow barges would be needed to transport and dump material into the ODMDS with haul distances ranging from approximately 5 to 18 miles one-way.

E. RELOCATIONS

29. General. The project sponsor would be required to assume the costs of all relocations and alterations.

30. Utilities. There are no known submarine crossings of local or long distance phone, cable television, electrical, sewerage or drinking water lines within the project limits. There are several outfalls and a set of JEA aerial electrical transmission lines as well as the Napoleon Bonaparte Broward (Dames Point) Bridge within the project vicinity as shown on Plate 38). It appears that all outfall pipes lie well outside of the channel and the design vessel operates well below the air-draft restrictions of the power lines and bridge, thus there are no relocations required in conjunction with Federal Navigation Project expansion.

F. SHIP SIMULATION STUDY

31. Discussion. Development of deep-draft navigation projects affected by tides, river currents, and wave motion requires the use of models and ship simulator studies. The dynamic environment embracing deep-draft navigation project sites can never be fully understood applying only the static tools of observation and measurement that engineering commonly uses. Designers and planners can discover and dissect the most efficient navigation system layout, with each of its component's individual geometry, by studying the performance of design vessel ship models, transiting project domain limits, depicted as proposed channel and turning basin system alternatives, on the ship simulator. Navigation model studies are used to determine the adequacy of a proposed project improvement plan and to develop possible design modifications to ensure project safety, efficiency, and minimum adverse impact to the environment. Because of the complexity of tidal and river currents and effects of wind, waves, and sediment movement on ship navigation, combined analysis of physical scale models, numerical models, and computer based ship simulation models is often necessary to resolve proposed project issues (EM 1110-2-1613, 31 Aug 2002, Chapter 13, Navigation Model Studies). The general guidance presented in this manual is based on average navigation conditions and situations. The design engineer will adapt these guidelines to the local, site-specific conditions of the project. And, unless special circumstances exist whereby a deviation is approved by Headquarters, U.S. Army Corps of Engineers, the final project design will be developed by application of a ship navigation study, incorporating real-time ship simulation tests with local professional pilots (EM 1110-2-1613, 31 Aug 2002, 1. Purpose, as stated in the cover letter signed by Joseph Schroedel, Colonel, Corps of Engineers Chief of Staff).

A deep-draft navigation study begins with meetings and discussions focused on navigation system improvements that are believed to be necessary for continued safe operation, by the professional harbor pilots who command vessels that use the channels and basins included in the system layout. Generally, the pilots suggest channel straight section and turn wideners that enhance vessel transit efficiency and safety. They may suggest new turning basin components, or construction that increases the diameter of existing turning facilities. As the vessel fleet increases its operating draft, the pilots advocate for increased channel depth. In special situations where a restriction to operations exists based on water currents, the pilots contribute time and efforts toward engineering investigations focused on removal of the restriction through the development of structural components that moderate water current force, and ease the flow of water through the system. These early discussions are conducted with engineers and planning specialists in attendance. The engineering team begins early to encourage movement of the study to the simulator environment, for efficient iterative development of the best alternative that will define project physical limits, and test a proposed design.

The engineering simulator design team observed vessel transits from the bridge of an inbound and outbound container vessel, as the harbor pilot guided these transits to and from the vessel's berth at Blount Island. It is common practice to board a vessel during operation, under supervision of the harbor pilot, to observe vessel movement through the system, and witness operation within the constraints of the existing system layout. These transits clarify operation inefficiencies, and sharpen their focus for accurate presentation on the simulator. The simulator design team can do their best work at problem solution when the problem is fully understood and accurately duplicated for investigation in the simulated environment. This important component of simulator preparation occurred on February 24 and 25, 2009. During these transits, the simulator design team collected digital photographic images of the navigation channel and adjacent shoreline features. These images become the visual scene component of the simulator presentation that represents the channels, basins, and shoreline, with adjacent and nearby background areas. During navigation, in addition to channel limit markers and course range delimiters, the harbor pilot references shoreline features that he associates with acceptable progress along an intended sailing course. These visual cues are coincidentally noticed, habitually learned, and eventually relied upon, as the pilot gains experience in a particular harbor channel network.

In addition to the visual component of the simulator experience, the geometry of the channel layout with adjacent shoreline and berthing areas is entered into the simulator computer data base. The geometry of the existing condition at the facility, in addition to the geometry of alternative channel layout configurations that include pilot suggested improvements, is entered into the computer data base for testing. The dynamic features of the simulator are entered as water currents, wind, and hydrodynamic ship forces. Bridge command forces in the form of engine throttle setting and steering rudder position complete the dynamic input to the model. During simulator testing, a professional harbor pilot navigates a hydrodynamic model of the project design vessel through the simulator domain of the proposed project alternatives, to select and test the best configuration that satisfies intended project purpose feasibly, with full accommodation for navigation safety and environmental preservation.

Model development for the GRR-2 and testing of alternatives were completed during the period January to December 2010. This work included two testing sessions attended by the St. Johns Bar Pilots, and a testing session focused on turning basin placement and dimensioning, attended by the professional Docking Masters. A detailed report of this work is included in Attachment I. Ship Simulation Navigation

Study for St. Johns River GRR-2 Improvement Project Data Report, March 2012). The report discusses each component of simulator development and utilization for selection and testing of the GRR-2 recommended Alternative. In addition to the above, the report includes testing track plots and pilot evaluations of each simulated run conducted. The track plots and the evaluations are considered intellectual property of the pilots and may be viewed at the USACE District Office in Jacksonville .

G. OPERATION AND MAINTENANCE

32. General. The Federal Government currently maintains the existing project annually. The Federal Government would be responsible for operation and maintenance of the improvements to the Federal Navigation project proposed in this report upon completion of the construction contract. The local sponsor, JAXPORT, would be responsible for the costs of the construction and maintenance dredging of all Port Berthing Areas. JAXPORT is also responsible for the costs of infrastructure improvement of the port facilities, some of which are scheduled to be completed in advance of the authorization of the Federal navigation improvements.

33. Estimated Annual Cost. Based on a desktop analysis of the existing O&M requirements and the proposed project expansion features, it is estimated that there will be an average annual increase of 132,000 cubic yards (CY) of shoal material to be dredged each year from the new project. Details regarding future O&M dredging and disposal requirements can be found in Appendix P – Dredged Material Management Plan of this report. Much of the increase is due to the construction of two new turning basins that will be needed to accommodate the post-panamax container ships. With the incorporation of advance maintenance zones into these turning basins, it may be possible to reduce the frequency of dredging required and thus reduce contract costs and equipment mobilization costs. Specific costs related to the anticipated future O&M requirements due to the proposed navigation improvements can be found in the MCACES estimate presented in the Cost Appendix of this Report.

34. Navigation Aids. The U.S. Coast Guard (USCG) would be responsible for providing and maintaining navigation aids. Due to the proposed widening measures there are an estimated eight Range Towers that will require relocation and the USCG has provided an estimated cost for this effort. In addition, there will need to be a relocation of several buoys within the project limits once dredging has been completed. These costs are incorporated into the MCACES estimate in Appendix N.

H. QUANTITIES AND COST ESTIMATES

35. Summary of Quantities. A summary of the major construction items are presented in Table 4 below. Mitigation construction quantities are discussed in the Mitigation Plan, Appendix E.

36. Summary of Costs. The estimates of first cost for construction of both the NED and LPP Plans were prepared using MCACES software and are presented in the Cost Estimates and Cost Risk Analysis, Appendix N. The estimate includes a narrative, a summary cost, and a detailed cost showing quantity, unit cost, and the amount for contingencies for each cost item. The costs of the non-construction features of the project are also included in the cost estimate. Costs are currently provided assuming all dredged material disposal will be at the ODMDS.

The costs have been prepared for an effective date of Fiscal Year 2013 (FY13).